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[This white paper entitled "Expectation for Science and Technology: the Source of a More Fulfilling Life," is an "informal summary" prepared by the Science and Technology Agency in cooperation with the Foreign Press Center, Japan.]

CONTENTS

Introduction

Progress in science and technology has played an important role in the development of the economy and society and the improvement of human life by pioneering new fields of human activity and providing superior production methods.

Supported by scientific and technological development, Japan has matured into an economic giant that produces 14% of the world's GNP. In recent years, the people's consciousness has been transformed in the midst of this economic prosperity, and they now wish to live their lives in comfort and fulfillment.

In response to this change, the theme chosen for this year's White Paper on Science and Technology is "Expectation for Science and Technology: the Source of a More Fulfilling Life." Rather than analyzing the contribution which science and technology make to economic growth, the white paper considers their roles from the standpoint of ordinary people and attempts to show how science and technology contribute to the creation of a satisfying life based upon comfort and fulfillment, in addition to economic prosperity and convenience. It also clarifies the fact that it is a variety of technologies which support a rich life and that, in many cases, the achievements of basic, leading research have contributed to the success of these technologies.

This paper is presented in four parts. Part 1 is a survey of the present state of science and technology in Japan. Part 2 presents an analysis based upon the theme of the white paper. Part 3 examines the science and technology policies in various countries, international comparisons of the state of science and technology, and the present situation in Japan. Part 4 is a consideration of concrete science and technology policy that is promoted in conformity with the General Guidelines for Science and Technology Policy, the fundamental statement of Japanese science and technology policy.

Part 1. Present State of Science and Technology in Japan

I. Trends in research and development activities in Japan

(The level of research and development in Japan)

A summarization has been prepared of Japanese research and development activities by examining both research and development input indicators and output indicators. The input indicators are research & development expenditures and the number of researchers within Japan. The output indicators include the value of technology exports, the value of high-tech products exports, and the number of research papers published.

Let us begin with a look at the input indicators.

(1) In 1988, total R & D expenditures reached ¥9.8 trillion (¥10.6 trillion, if humanities and social sciences research is included): an increase of 46% during the previous 5 years (real terms) (Figure 1).

(2) There were 462,000 researchers (535,000 including the humanities and social sciences) in Japan on April 1, 1989: an increase of 25% during the previous five-year period (Figure 2).

Next, let us look at the output indicators.

(1) The value of technology exports in 1989 was ¥280 billion, a 190% jump during the previous five-year period.

(2) The value of exports of high-technology products in 1986 reached ¥11.6 trillion, an increase of 93% in four years.

(3) In 1986, the world's leading scholarly journals published 30,000 papers written by Japanese researchers. This was 19% more than the number published 5 years earlier (Figure 3).

Japan is second to the United States in terms of total R & D expenditures and in its number of research personnel, but it is behind other countries in terms of the proportion of its R & D which is funded by the government. R & D expenditures by the government comprise 0.6% of Japan's GNP,

about half as much as in the United States, West Germany, and France. But the value of Japan's high-tech products exports is the highest in the world: a reflection of the strength of its manufacturing technology (Figure 4).

(Research and development activities by sector)

- Government Research Institutes and public research corporations -

In 1988, R & D expenditures by national government institutes amounted to ¥470 billion, and those of the public research corporations came to ¥430 billion. The expenditures of the two sectors increased 20% and 46% respectively during the previous five-year period. In 1989, there were 24,000 researchers working in government research institutes, 1% fewer than there were 5 years earlier. The research personnel active in public research corporations rose 19% in the same period to reach 3,000. These research organizations are involved in the continuous task of updating their activities and improving their organizations, a necessary process if they are to continue to respond appropriately to the new requirements which society asks them to satisfy.

One example of this ongoing process of essential organizational reform is the reorganizations in 1990 of the National Institute for Environmental Studies and the National Research Institute for Earth Science and Disaster Prevention, reorganizations carried out to strengthen research on global environmental problems.

In 1989, the Research Development Corporation of Japan was reorganized and assigned a new responsibility to promote not only basic research on advanced technologies but also international research exchange activities.

- Universities and colleges -

R & D expenditures in this sector rose 12% in the five-year period ending in 1988 to reach ¥1.2 trillion. In 1989, the universities and colleges employed 130,000 research personnel, a 15% increase the preceding five-year period.

Beginning in 1987, some universities began setting up joint research centers to promote cooperative industry-university research activities, and, at the national universities, contract research and contract researcher acceptance programs are being fully implemented.

- Private Industry -

R & D expenditures and researchers have been increasing more quickly in the private sector than in the government research institutes, the public research corporations, and universities and colleges. Expenditures in 1988 reached ¥7.6 trillion, a 56% increase in the previous 5 years, and the number of researchers increased 32% to 300,000 in the five-year period ending in 1989.

Private business stresses basic research because it is the source of revolutionary new technology, which in turn opens the door to new business opportunities. Businesses are also participating in the internationalization process by establishing laboratories as well as manufacturing plants overseas.

II. Development of science and technology policy in Japan

(Strengthening Japan's basic research capabilities)

The government is taking aggressive action in an effort to increase the nation's strength in basic research: an activity which plays an important role in preparing the soil in which we can cultivate future generations of technology.

The Special Coordination Funds for Promoting Science and Technology, appropriated by the Science and Technology Agency, exists to conduct, in accordance with the policies of the Council for Science and Technology, over-all promotion and coordination of important research activities which are necessary to promote leading as well as basic research in science and technology. In addition to the comprehensive joint research program which it has been overseeing since its establishment in 1981, it has initiated Encouragement of Basic Research to expand the basic research activities of the national research institutes, and an Basic Research core system to promote basic as well as leading research by combining the skills of researchers from various government agencies and even from overseas.

On top of this, the Science and Technology Agency is promoting research which is intended to lay the groundwork for creative science and technology through the Exploratory Research for Advanced Technology. At the same time it encourages research to discover the new knowledge which will be the main force behind a 21st century technological

revolution, conducted by the Frontier Research Program of the Institute of Physical and Chemical Research.

Other ministries are also involved in the promotion of basic research. For example, MITI has established the Next-Generation Fundamental Industrial Technology Research and Development Program; while the Ministry of Health and Welfare is implementing the Welfare Science Research Subsidy. At the Ministry of Agriculture, Forestry and Fisheries, the Advanced Biotechnology Research and Development program is underway, and the Ministry of Posts and Telecommunications is conducting a program which it calls Research on the Frontier of Telecommunications. The Ministry of Education is encouraging highly original scientific research in the university community by using the priority area research program to substantiate the scientific research subsidy system. The Science and Technology Agency and MITI have established and are supporting the activities of the Human Frontier Science Program, which was established to cooperate with international researchers in the performance of basic research related to the elucidation of the functions of living organisms(Table 5).

(The encouragement of international cooperation and international exchange programs)

With Japan continuing to internationalize, the government is being looked to for major policies to promote international cooperation and exchanges in science and technology.

Various programs to achieve these goals initiated in 1988 are in the process of expansion. These include the Science and Technclogy Agency Fellowship Program intended to bring foreign researchers to work in Japan's national research institutes and universities; the Japan Society for the Promotion of Science Postdoctoral Fellowship for Foreign Researchers and the International Research Exchange Program operated by MITI's Agency of Industrial Science and Technology (Table 6).

The Human Frontier Science Program (HFSP), proposed by Japan at the Venice Summit in June 1987, is intended to promote international cooperation in basic research elucidate the sophisticated and complex mechanisms of living organisms. The International Human Frontier Science Program Organization to implement the HFSP was established in Strasbourg, France in October 1989. And the first awards were made in March 1990.

(Tackling large-scale research projects)

Large-scale research projects in the atomic energy, space, oceanographic fields and so on, require a great deal of money and many people, and take a long time to achieve results. For these reasons they are conducted by public research corporations etc.

Japan is active in the development and utilization of atomic energy. Atomic energy is poised to become one of the nation's key sources of energy. At the same time that Japan is reinforcing safety maintenance measures, it is moving ahead with programs to improve light-water reactors, establish a nuclear fuel cycle, and conduct research and development on new kinds of power reactors such as "Monju," a prototype fast breeder reactor, and nuclear fusion in the JT60 project, for example. Work on the development of the Heavy Ion Medical Accelerator in Chiba is also underway in Japan.

Japan is also playing a role in the development and the utilization of space, another new area of human activity. Based on the establishment of foundation technology, it is pushing ahead with development of artificial satellites, including scientific satellites, geostationary meteorological satellites, marine observation satellites, communications and broadcasting satellites, and it is also working on space-transportation technology.

Japanese research activities related to the development of oceanic resources include the development and operation of the "Shinkai 6500", a deep-ocean submersible survey vessel, and the study of the unique ecosystem that exists deep under the surface of the oceans.

(Strengthening the infrastructure for science and technology promotion)

The advancement of science and technology in a wide range of fields is impossible without a science and technology promotion foundation to support it. This foundation includes elements such as equipment, facilities, information-distribution systems, genetic resources, and so on.

The Science and Technology Agency is promoting the next-generation synchrotron radiation facility (SPring 8) at the Harima Science Park City in Hyogo Prefecture. The SPring-8 will be used for projects related to basic research in many fields: the science and technology of materials, the life sciences, and photochemistry technology.

In the national research institutes, progress is being

made in the development and provision of the most up-to-date equipment and facilities as part of an effort to deal with the deterioration and aging of their equipment and facilities.

Information distribution systems are being augmented by efforts to establish a full-fledged international science and technology information-distribution system. For example, in November 1987, an international science and technology information network was formed cooperatively by three organizations: the Japan Information Center of Science and Technology, the Chemical Abstracts Service in the United States, and West Germany's Karlsruhe Specialized Information Center.

A number of ministries are involved in the task of guaranteeing a supply of genetic resources by establishing plant-and animal-cell cultivation, gene, experimental animal, and gene bank facilities.

(The study of science and technology policies for the coming century)

In the future, science and technology will be expected to do even more that it is doing now to deal with the problems facing society and with changes in the environment both in Japan and abroad. In June 1990, the government submitted the 18th Inquiry entitled, "Comprehensive Basic Science and Technology Policies to be Adopted in the New Century" to the Council for Science and Technology, and, based upon its image of what Japan should be in the 21st century, which is only a decade away, it is now conducting a study intended to establish comprehensive basic science and technology policies to be implemented in the future.

III. Recent changes in science and technology in Japan

(Expectations of a contribution to science and technology on a global scale)

With the help of scientific and technological development, Japan's position in the world has risen remarkably, and it now produces 14% of total world GNP. In the future, Japan should act as a "Japan coexisting with the nations of the world," and make a contribution to the world commensurate with its international status.

In September 1988, the Ad-hoc Committee on International

Affairs at the Council for Science and Technology presented the following opinion. "It is essential to adopt a global position which treats products of basic research as international public property to be shared by all nations, and to play a leading independent role in order to strengthen basic research at the same time as we work to promote science and technology based upon a global perspective."

In the future Japan will be expected to strengthen its basic research capabilities by creating a research environment which will attract superior researchers from both Japan and abroad, and to make positive efforts to conduct exchanges in research personnel to promote international cooperation and exchanges in science and technology.

(The trend to international large-scale research projects)

The increasing sophistication of science and technology has been accompanied by an increase in the range of projects which cannot be carried on by a single nation. Examples include the construction of a space station, nuclear fission development, and the construction of cyclotrons. One consequence of this trend is a rise in the number of such projects built and operated as international cooperative efforts.

Japan, the United States, Canada, and European nations are cooperating on the plan to build a space station, a project intended to provide the foundation for the full-scale utilization of space. A conceptual design of the International Thermonuclear Experimental Reactor (ITER) is being carried out by a four-party group: Japan, the United States, the EC, and Soviet Union, with the assistance of the International Atomic Energy Association (IAEA). International cooperation is behind the plan for the Superconducting Super Collider (SSC) in the United States. The SSC is expected to contribute to the clarification of the properties of elementary particles, the fundamental constituents of matter.

Furthermore, the human genome analysis project, the goal of which is to achieve a complete analysis of human genes, is being conducted jointly by the United States, Europe, and the Soviet Union. In Japan, the Council for Science and Technology and other committees are studying the character of future research involved in the human genome analysis project.

(Response to global environmental problems)

In recent years global environmental problems have become a serious issue as they threaten the very foundations of human existence, and solutions to these problems must be found as soon as possible. They have been placed on the agenda at a series of summit meetings, and conferences between the leaders of various nations, and fast acting counter measures are under investigation. Science and technology are expected to play an active role in dealing with these problems. A Cabinet-level conference on the preservation of the global environment held in June of 1990 prepared the 1990 Global Environment Preservation Study and Comprehensive Research Advancement Plan, and demonstrated the need for research and development on technology related to observation and surveillance using artificial satellites, the clarification and the forecasting of all global phenomenon related to global environmental problems, the regulation of fluorocarbons and other factors placing a burden on the environment, and the conservation of resources and energy. The same month the report on the 17th Inquiry entitled, " Basic Plans for Research and Development on Earth Science and Technology" was submitted to the Prime Minister. It described Japan's basic attitude, major research and development themes, and an implementation policy which it should employ in its efforts to tackle global environmental problems using science and technology.

Based upon the basic concepts prescribed in the above report and so on, the advanced countries, including Japan, are achieving advances in the use of artificial satellites to perform global observations, research to clarify all phenomenon including the forecasting of warming trends, and the development of substitutes for fluorocarbons which will not destroy the ozone layer.

(Changes in the social environment)

As mentioned earlier, the continuous economic growth which Japan has achieved has not only elevated its status in international society; it has also transformed the consciousness of the Japanese people. In sum, people are no longer solely concerned with the quest for simple economic gain in their daily lives; each one also wants to achieve a more fulfilling life in a way best suited to his or her own individual character.

In the past, science and technology were the driving forces behind economic growth, but with this transformation in human consciousness, science and technology are now expected to contribute to the creation of a rich life based on comfort and fulfillment.

Part 2. Expectation for Science and Technology: the Source of a More Fulfilling Life

History reveals that science and technology, the forces behind human development, have brought social progress and built civilizations.

The great extent of the contribution which science and technology make to economic growth is shown by an analysis, contained in the 1990 edition White Paper on economy, which shows that on the average, two-fifths of actual economic growth achieved during the previous 10 years was produced by technological progress. But science and technology do more than simply drive economic growth; they are the forces which enrich our lives both quantitatively and qualitatively, and the people expect a great deal of science and technology (Figure 7).

For this reason, this white paper analyzes the way science and technology contribute to the enrichment of the lives of the people, but not from the usual standpoint which looks only at the effects of science and technology on economic growth. Part 2 adopts this attitude, and focuses on aspects of the foundation of a more fulfilling daily life, and in which science and technology are expected to make a major contribution to its achievement. Chapter 1 gives examples of ways in which our lives have been enriched by pioneering frontier areas, while Chapter 2 presents an analysis from the point of view of ordinary people of the concrete ways in which science and technology contribute to the foundations of a satisfying life. Chapter 3 is a quest for issues and future prospects concerned with the creation of an abundant life.

Chapter 1. Pioneering Frontier Areas and a More Fulfilling Life

Frontier areas, in other words, the curiosity-driven exploration of unknown spheres such as the origins of space, life, and the essential nature of material, have provided mankind with new knowledge, allowed us fresh ways of looking at the world and at life itself, and have acted as one of the forces behind historical progress. There is a tendency for the exploration of these frontier areas to appear isolated from daily life if one does not consider them very deeply, but

research to advance the exploration of these frontier areas, i.e., basic, leading research, provides us with new points of view based upon scientific information and enhances the intellectual wealth of humanity at the same time that it contributes to the enrichment of daily life by bearing fruit in the form of a variety of technological achievements.

Chapter 2. Science and Technology from the Point of View of the Average Citizen

This chapter deals with three areas which form the foundations of a more fulfilling life, and in which science and technology are expected to make a major contribution to its achievement: (1) a healthy body, (2) a comfortable and safe environment, and (3) the extension of the range of human activities; and provides concrete examples of how various areas of science and technology have contributed to each of them.

1. A healthy body

(1) Maintenance and improvement of health

As people's consciousness of health increases, they become more likely to attempt to maintain and improve it. To maintain and improve one's health as part of one's daily life it is necessary to have suitable indices to judge the state of one's own health, to acquire the right amount of rest and maintain a balanced diet, and to get an appropriate amount of exercise. The wide dissemination of knowledge obtained from the life sciences concerning nourishment and rest can play a part in maintaining people's health. It is also beneficial to increase people's basic knowledge of the mechanism of metabolism: what happens to food inside their bodies. Knowledge of the mechanisms of sleep and relaxation, which are important aspects of rest, should be expanded, and guidelines and equipment which permit people to rest effectively should be popularized. Training equipment designed upon a knowledge of sports medicine should be popularized, and an area of sports medicine adopted to the needs of elderly people who wish to be active should be developed.

(2) Diagnosis and treatment

Diagnostic equipments such as X-ray equipments, and, later, ultrasound devices and others, have been developed to assist in diagnosis by monitoring physical phenomenon. The

development of such equipments owes a great deal to progress in material technology such as sensors and information processing technology. For example, the development of X-ray computed tomography imaging diagnostic equipment (X-ray CT) was possible in large part only because of the material technology which provided the sensors to measure X-rays, and progress in the information-processing technology used to process data on the absorption rate of the X-rays which are detected by the sensors and create images based upon these data. To create new technology based diagnostic methods it will be necessary to conduct research on the human body and to expand our basic knowledge of diagnostic procedures themselves (Figure 8). In the treatment field the development of new pharmaceutical products, such as anti-cancer medicines, is proceeding at a brisk pace. New knowledge provided by life sciences research, in immunology and molecular biology for example, is making an important contribution in this field. It is believed that, in the future, progress in molecular biology, especially in research which clarifies human genetics, will produce a revolution in treatment technology. There is a growing demand for higher quality medical treatment: treatment which allows the patient to recover his or her original state of health, and to resume a normal life.

(3) Supplementing physical functions

Another issue growing in importance is the development of devices to make up for the loss of physical functions of handicapped persons and the declining physical capabilities of the aged, so that persons handicapped as a result of accident or disease and the increasing number of elderly people can live as active members of society. It is important that devices used to supplement people's senses, such as sight and hearing, and artificial organs and mobility aids that provide handicapped persons with complete bodily functions be easy to use and highly compatible with living organisms.

2. A comfortable and safe environment

(1) Protecting the global environment

It is pointed out that our planet is becoming warmer because of increased carbon dioxide in the atmosphere due to the combustion of fossil fuels. It is predicted that, if the quantity of carbon dioxide in the atmosphere continues to increase at its current rate, the average global temperature will increase about 1 ^{o}C by the year 2025, and the surface of the oceans will rise about 20 centimeters by the year 2030 (Table 9). There is some concern that global warming could

have a significant effect on human life as unusual climatic conditions accompanied by increased sea water and the melting of the polar glaciers raises the level of the surface of the oceans.

The development of new energy sources such as solar-power generation, wind-power generation, and wave-power generation is expected to reduce the burden placed on the environment. It is also believed that the problem will be alleviated by the development and use of atomic energy power generation, a stable form of energy production that does not produce carbon dioxide. Progress is being made on the development of new kinds of reactors, including fast breeder reactors, which are expected to be the next generation atomic reactor. The transportation industry hopes to contribute to the reduction of carbon dioxide with the development of electric and solar cars. Energy conservation technologies that promise to contribute to the solution of this problem include exhaust-heat-utilization systems and super-conductor utilization technology (Figure 10).

It has been verified that the fluorocarbons that are used to clean semiconductors are destroying the ozone layer that absorbs the Sun's ultraviolet rays, which are dangerous to living organisms. It is absolutely essential that substitutes for fluorocarbons that will not harm the ozone layer be developed in order to eliminate the use of all specified fluorocarbons by the year 2000.

There is a pressing need to measure and observe the density of carbon dioxide and fluorocarbons in the atmosphere, to use this data to clarify the mechanism of global warming and destroying the ozone layer, and thereby create a dependable forecast model.

In the long term, we need to find an "environmentally gentle" scientific and technological system which will not place a burden on the environment. This new scientific and technological system will feature a utilization technology that permit nuclear fusion to serve as the ultimate energy sources and solar power, high-temperature superconducting materials, normal-temperature, normal-atmospheric-pressure industrial chemical processes, and biodegradable plastics (Figure 11).

(2) Protecting the regional environment

The development of sulphur oxide gas and waste-water-processing technologies have contributed to the alleviation of

water and air pollution in Japan by reducing the degree of contamination in the atmosphere and the water. New developments in catalytic technology have enabled Japan to eliminate the sulphur content from petroleum: the original source of atmospheric sulphur dioxide gas. Purification technology based on catalytic action has reduced the volume of nitrogen oxides and carbon monoxide in automobile exhaust gasses. The use of science and technology to remove all the waste materials from the environment in which we live, and to prevent the contamination of the environment from ever occurring is our ideal.

In the future, it will be critical to minimize the production of waste material, and to develop technology that enables us to use waste matter as a resource. We are also looking to private industry to play its part in reducing the burden on the environment by developing biodegradable plastics and products manufactured on the premise that they will be recycled.

(3) A safe society and a comfortable living environment

Guaranteeing people a safe society and a comfortable living environment is a key issue fundamental to life. As sophisticated networks built around information and communication technologies become an increasingly ubiquitous aspect of the social environment, their reliability is being enhanced through the use of multiple-protection systems equipped with subsystems designed to guarantee the safety of the networks. However, there is a need for even greater reliability by adopting counter measures to prevent a breakdown in the network through the willful disruption of its functions, and to protect it from invasion by computer viruses.

The provision of a comfortable living environment through the prevention of fire and theft, and the guaranteeing of the safety of the population are other important tasks. Progress is being achieved in the development and use of home security systems equipped with sensors that detect fire, intruders, and gas leaks to keep our homes safe.

Japan is behind Europe and the United States in the use of design techniques that create comfortable living spaces (Figure 12). One promising way to make the interior of our homes more comfortable is to adopt design concepts suited to the limited ability of elderly residents, and use them to create living spaces which are easy to take care of and move around in. It is critical to analyze human activities and

human feelings, and provide appropriate living environments based on the results of this analysis (Figure 13).

3. Extending the range of human activities

(1) Extending mobility

By providing greater speed and capacity, land, air, and ocean transport systems have enhanced human mobility. The fruits of future research on the science and technology of space and materials, such as superconductors, are expected to lead to the development of even faster transportation systems. The foundations of transportation technology, namely roads, railway tracks, harbors, and airports, have very long lives, and make a significant contribution to the communities they serve. For these reasons, it is essential to obtain new knowledge through scientific and technological progress in the development of methods of integrating all the elements which make up the social system -- the cities, transportation, and the living environment. Then we must use this new knowledge to expand our understanding of their effects on social systems and enhance our overall transportation-system-design capabilities (Figure 14).

(2) Extending information processing and communication abilities

In the information and communications fields, progress in both electronics and materials technology, which support electronic advances, have reduced the size and enhanced the functions of word processors, portable telephones, facsimile terminals, and many other devices. The popularization of these devices in the home has expanded people's information processing and communications abilities. Continued improvement in electronics technology is expected to provide smaller, higher-performance equipment. The development of optical and satellite communication technologies will increase the volume of information communicated, bring greater diversity to broadcasting, and create a variety of new media forms. Further expansion of our communications capabilities will enable us to transmit highly detailed visual images.

Chapter 3. Issues and Prospects for the Creation of a More Fulfilling Life

1. We can now sum up the results of the above analysis of

science and technology and the enrichment of human life.

(1) It responds to people's needs by providing a varied "technological menu" and enriching their lives. We expect that the completion of this menu will enable them to lead even richer lives than they do now.

(2) Those technologies which compose the technology menu include many which are the products of what we call basic, leading research, such as the science and technology of materials, the life sciences, and the science and technology of information and electronics.

(3) It is important that when we select and utilize the ideal technology from the technology menu, we base our decision upon scientific knowledge. This scientific knowledge is also a product of basic, leading research.

2. Basic, leading research appears at first glance to be unrelated to the daily lives of ordinary people, but its achievements frequently result in the appearance of diverse technologies that meet the requirements of ordinary people, and in the long term, these achievements ultimately enrich their lives. The public sector must play a major role in basic, leading research of this kind: research which private industry can rarely undertake because it is either extremely risky or requires a big investment in time.

3. In order to employ these varied technologies in the task of enriching the lives of the people, we must choose the appropriate technologies and implement them smoothly. To do so, it is necessary to consider the safety of the technology and its effect upon the environment, work to rationalize standards and regulations as we adopt the new technology, and endeavor to obtain the sympathy and the cooperation of the public by providing accurate scientific and technological information.

4. The people of the world, the Japanese among them, are increasingly eager to live more fulfilling lives than they do now. Science and technology will contribute to the creation of a society which will satisfy their longing for such comfort. Based upon science and technology that will be gentle both with the environment and to the people living in it, this new society will be what we have named a "Techno-amenity Society," one in which each person can enjoy benefits suited to his or her individual requirements.

Part 3. Science and Technology Activity Overseas and in Japan

Chapter 1. Science and Technology Policy Around the World

The governments of the world's leading nations are all taking positive action to position science and technology policies at the center of their political programs. Their goals are to challenge human potential, deal with international problems (including global environmental problems), and increase their nations' industrial competitive strength. In an effort to achieve future growth and to expand the human frontier, The United States has committed itself to the priority funding of research and development, space, and education, and is stressing the implementation of National Science Foundation's budget appropriations doubling plan, research on global-scale environmental changes, and research and development on advanced technology. West Germany has reduced assistance to industry, and is increasing its financial support of national projects such as basic research and space development. Eager to strengthen its science and technology, France has declared its intention of increasing the share of its GDP spent on research to 3% by 1995, and is expanding public research institutions, and increasing its investment in high-technology fields and large-scale research and development programs.

The developing Asian countries included in the NIEs group and those belonging to ASEAN are also improving their science and technology policies, particularly those intended to introduce technology and cultivate human resources in order to increase their stock of industrial technology.

Chapter 2. International Comparison of Science and Technology and the Situation in Japan

Science and technology indices indicate that the United States is the overwhelming giant in science and technology. Japan, West Germany, France, and the United Kingdom are all behind the United States in terms of R & D expenditures and numbers of researchers. R & D expenditures are tending to rise in all major nations (Figure 15), and as a percentage of GNP, expenditure figures for all countries indicate an increase in the level of science and technology activity (Figure 16). This trend is particularly remarkable in industry. In response to

increasingly severe international industrial competition, research and development activity in the industrial sector of all major nations is expanding quickly, especially in Japan (Figure 17). Changes in the proportion of research and development funded by governments reveal that this source of funding is declining in importance in all countries over the long term. This is a result of the brisk investment in research and development seen in the industrial sector. The share of Japanese research and development funded by the government is lower than it is in the United States and the major European nations (Figure 18). A comparison of the flows of R & D funds between the source and the user sectors in major countries of the world shows that in Japan there is less flow between various sectors and in particular, less flow from government to industry, than in other nations (Table 19). An increase in the number of researchers can be observed in all nations, and Japan's growth rate is the same as that of the United States. Japan's high rate is a product of the lively increase in research and development investment by the industrial sector (Figure 20). Technological trade, bolstered by increasing development of new products in all the major industrial nations, is growing everywhere (Figure 21). Supported by the powerful manufacturing technology of Japanese industry, the value of Japan's high-tech products exports is high (Figure 22). A comparison of the country of origin of papers published at major international scholarly journals shows the United States in the lead, followed by the United Kingdom, Japan, The Soviet Union, West Germany, and France (Figure 23).

With the governments and industrial sectors of major countries all implementing aggressive science and technology policies, it appears that Japan's international standing in science and technology is rising steadily.

Figure 1 · Growth in R&D Expenditures in Japan over a Five-Year Period

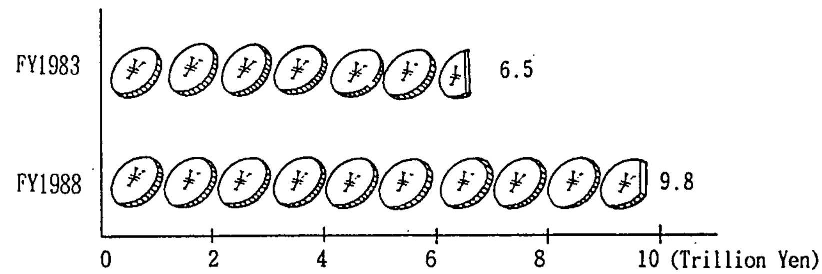


Figure 2 Increase in Researchers in Japan over a Five-Year Period

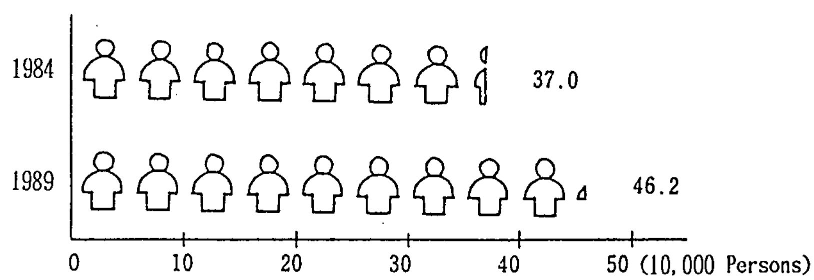
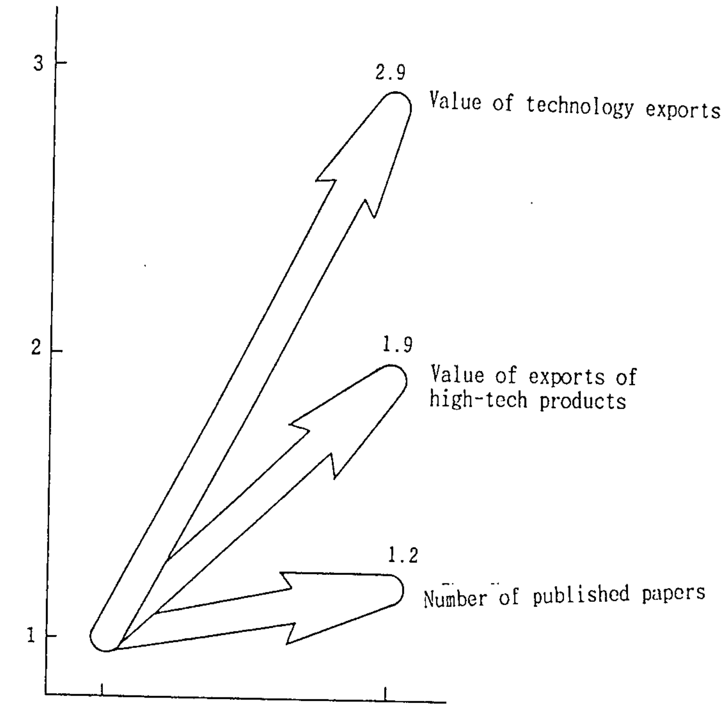


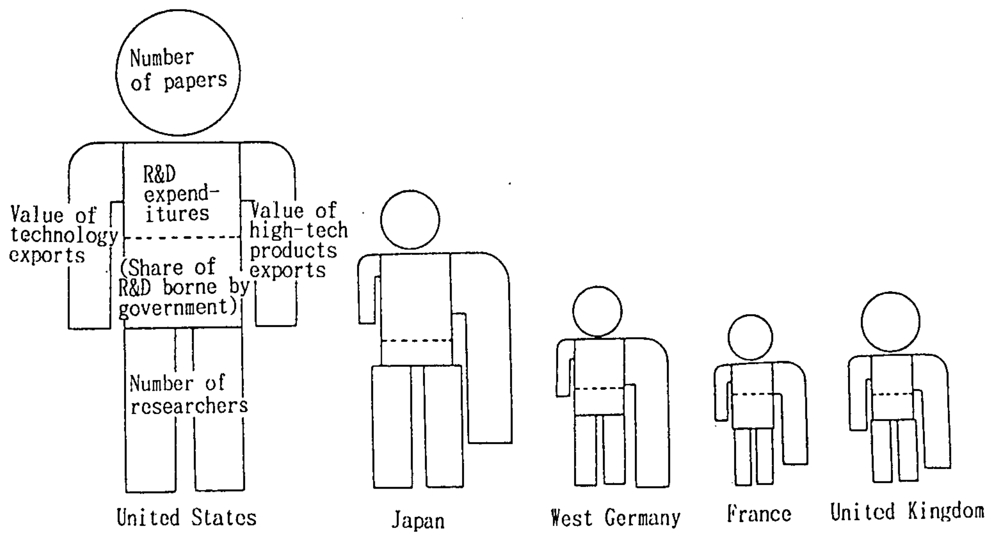
Figure 3 Growth in the Value of Technology Exports, the value of Exports of High-Tech Products, and the Number of Published Papers



Value of technology exports;	1984	1989
Value of exports of high-tech products;	1982	1986
Number of published papers;	1981	1986

Note) The value of technology exports in 1984, the value of exports of high-tech products in 1982, and the mumber of published papers in 1981 are each taken to be equal to 1.

Figure 4 R&D Expenditures, Number of Researchers, Value of Technology Exports, Value of High-Tech Product Exports, and Number of Published Papers for Major Countries



Notes) 1. The value of all indicators for the United States are equal to 1. The indices of the various countries are indicated by the relative size of each section of the figures.
2. All indicators are 1987 values with the exception of the high-tech export value figures which are 1986 figures.
3. Figures for number of researchers are "full-time equivalent" figures for every country except Japan.

Table 5 Major Basic Research Promotion Programs and Their Budgets

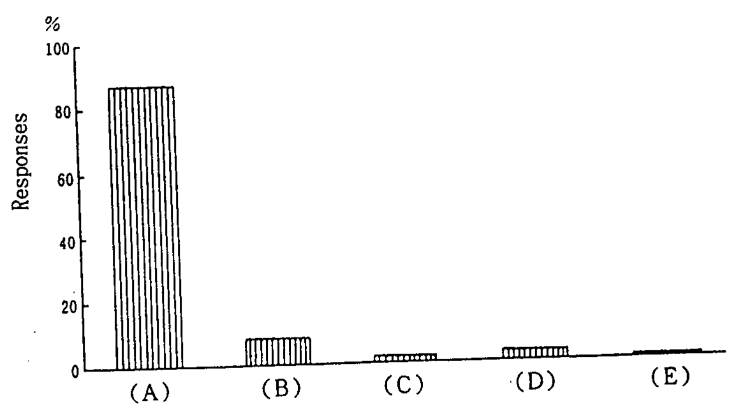
Agency Name	Program Name	Year Established	Budget (¥100 millions) 1984	1989
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	1981	63	101
	– Encouragement of Basic Research	1985	–	14
	– Basic Research Core System	1988	–	8
	– Special Science and Technology Researcher System	1990	–	2
	Exploratory Research for Advanced Technology (ERATO)	1981	23	46
	Frontier Research Program	1986	–	17
	Human Frontier Science Program	1989	–	15
	Special Researchers' Basic Science Program	1989	–	1
Ministry of Education	Scientific Research Expense Subsidy	1965	405	526
	Special Researcher Fellowship Program	1985	–	19
Ministry of Health and Welfare	Welfare Science Research Subsidy	1979	22	55
Ministry of International Trade and Industry	Next-Generation Fundamental Industrial Technology Research and Development Program	1981	60	68
	Human Frontier Science Program	1989	–	9
Ministry of Agriculture, Forestry and Fisheries	Advanced Biotechnology Research and Development Program	1984	5	8
Ministry of Posts and Telecommunications	Research on the Frontier of Telecommunications	1988	–	2
Various Ministries	National Research Institutes Operating Research Expenses		339	345

Table 6 Numbers of Foreigners Accepted by Major Fellowship Programs

(Unit: persons)

Program Name	Field	Year Established	1989
Science and Technology Agency, Fellowship Program	Sceince and Technology	1988	130
Japan Society for the Promotion of Science, Postdoctoral Fellowship for Foreign Researchers	Natural Sciences, Humanities and Social Sciences	1988	130
Agency of Industrial Science and Technology, International Research Exchanges Program	Natural Sciences (Industrial Technology)	1988	10

Figure 7 Contribution of Science and Technology to the Improvement of the Quality of Life



A. It should be increased.
B. The present level is satisfactory.
C. It should be reduced.
D. Other responses
E. No response

Source: "Survey of High-tech Researchers and Engineers"

Figure 8 Image Diagnosis Technology: Diversification and Diagnosis

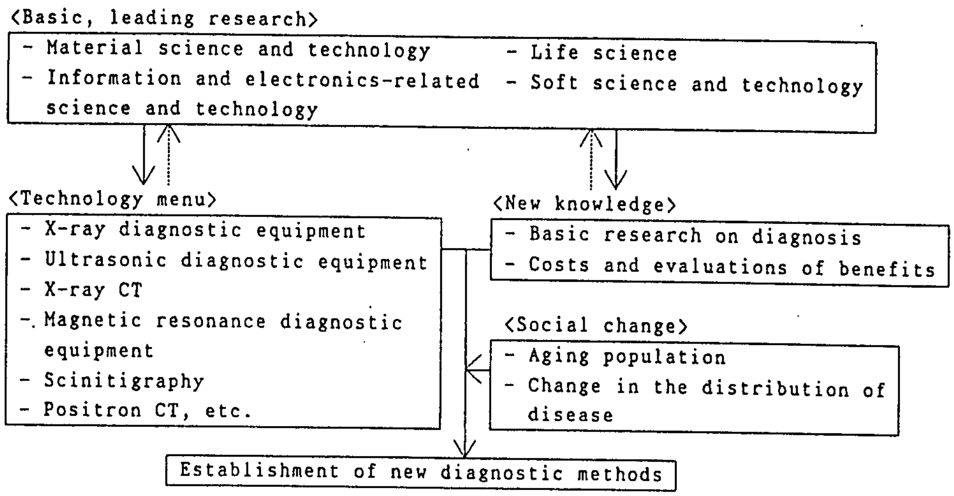


Table 9 CO_2 Emissions in Various Countries

	CO_2 Emission Volumes (1985)	Per Person (1987)	Per GNP (1987)
	100 million tons (%)	tons/person	tons/$1,000
United States	11.8 (22.4)	5.1	0.30
Soviet Union	9.0 (17.0)	-	-
China	5.3 (10.0)	-	-
Japan	2.3 (4.3)	2.4	0.18
West Germany	1.9 (3.5)	3.1	0.30
United Kingdom	1.5 (2.8)	2.7	0.32
France	1.0 (1.8)	1.8	0.18

Figure 10 Energy Diversification and Energy Supply

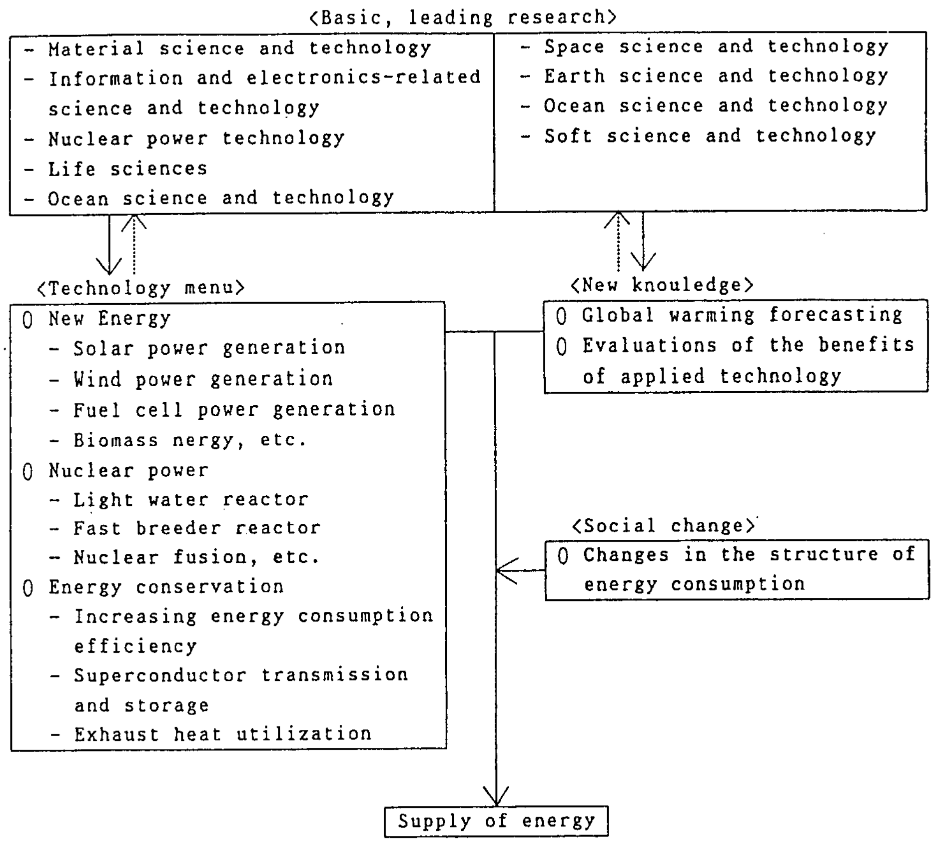
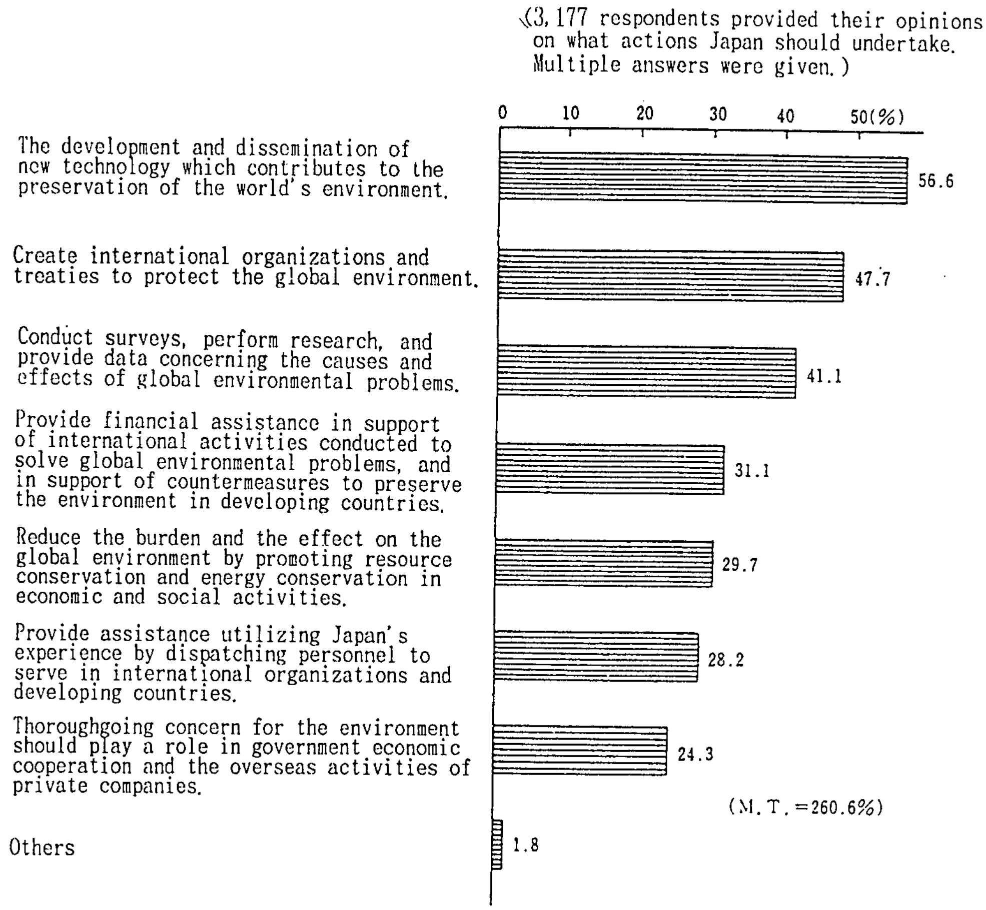
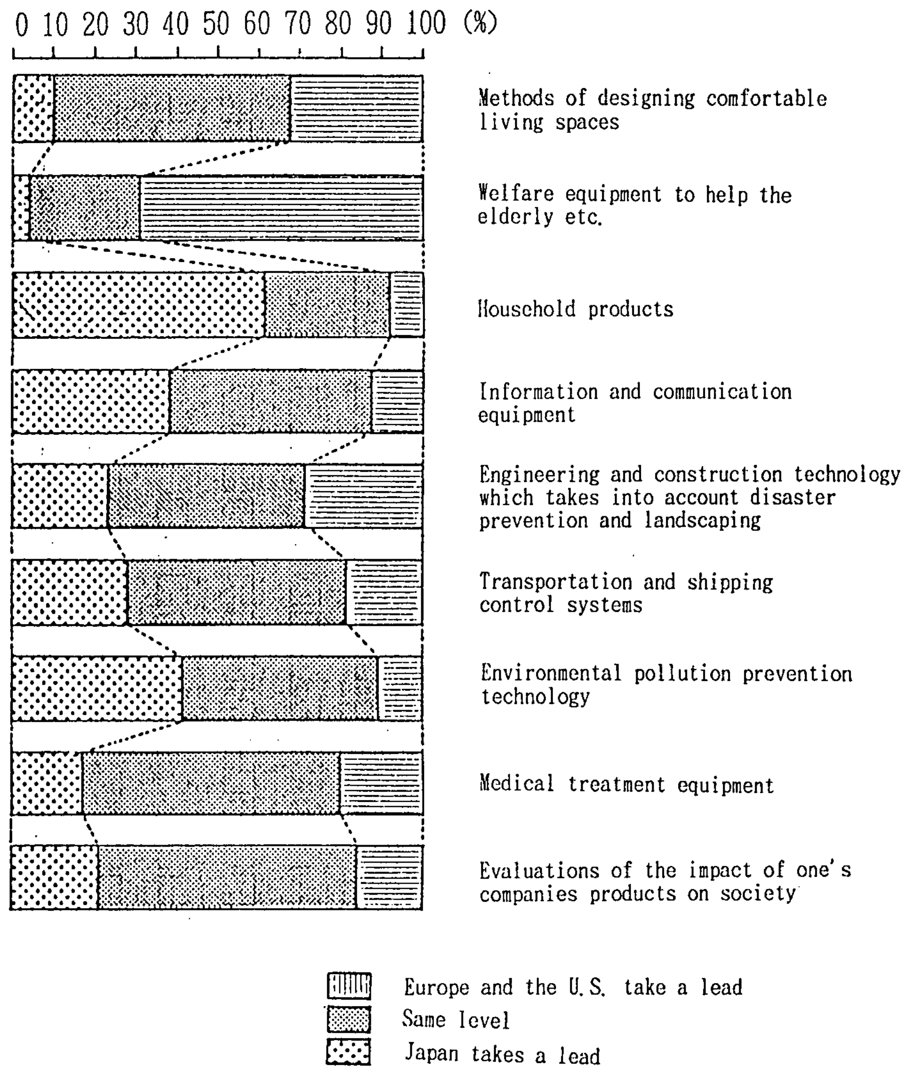


Figure 11 Actions Japan should Stress to Deal with Global Environmental Problems



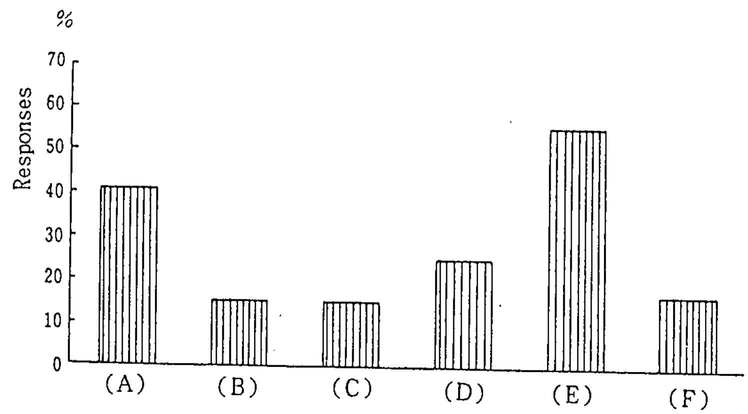
Source: Prime Minister's Office "Public Opinion Poll on Social Awareness" (January 1990)

Figure 12 Self-Assessment of Japanese Corporations' Technical Capabilities



Source: Science and Technology Agency "Survey on Private Enterprises' Research and Development" (1990)

Figure 13 Reasons for Not Using Technology to Complete the Living Infrastructure



A. Existing restrictions obstruct it.
B. Utilization standards (safety standards etc.) for the technology are not provided.
C. There is little demand, and neither the incentive nor the money to conduct research and development.
D. Because the technological development necessary for the creation of the living infrastructure is not advanced enough.
E. Public investment is insufficient, and the technology is rarely used.
F. Others
Source: "Survey of High-tech Researchers and Engineers"

Figure 14 Transportation Systems, and the Diversifications of Mobility Technology

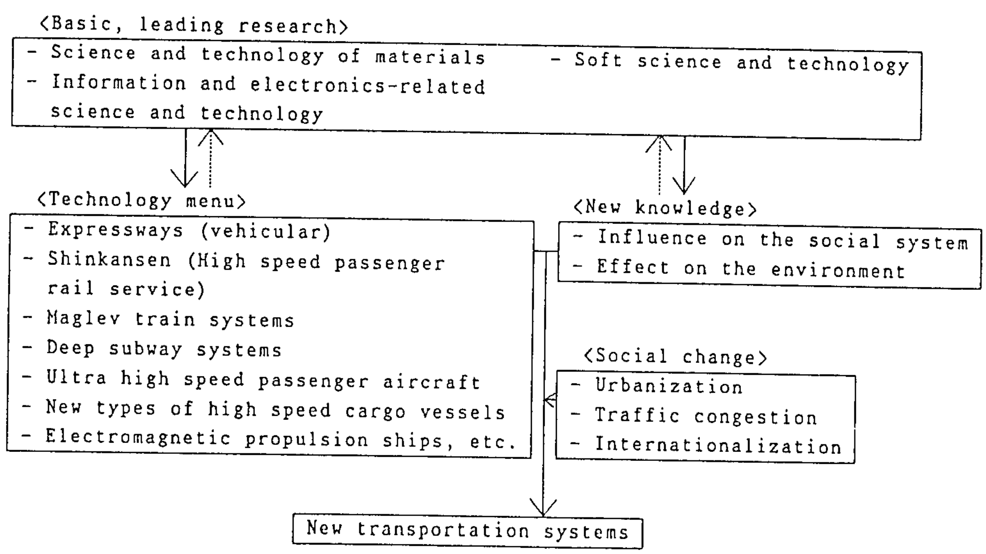
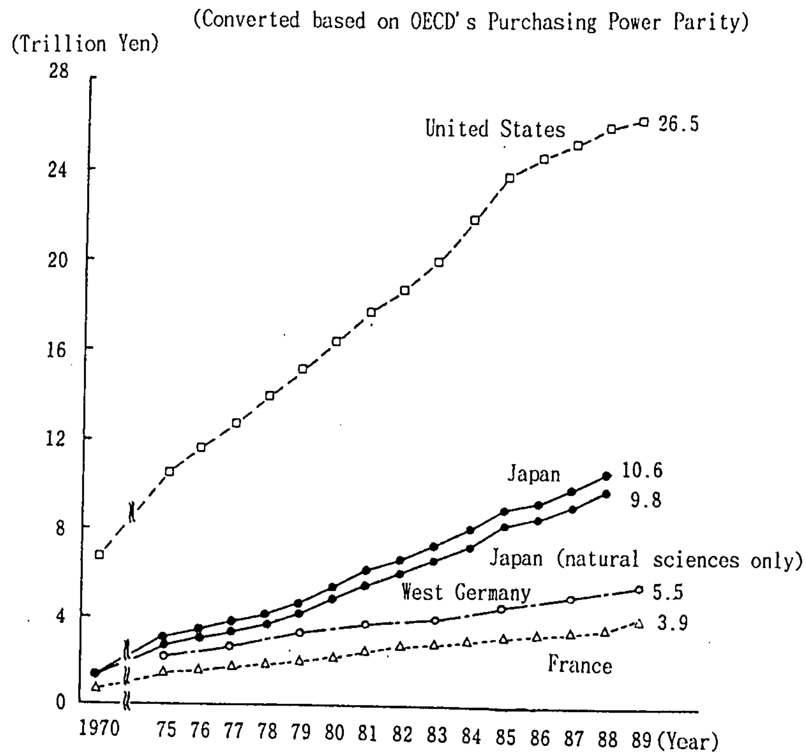


Figure 15 Changes in R&D Expenditures in Major Countries

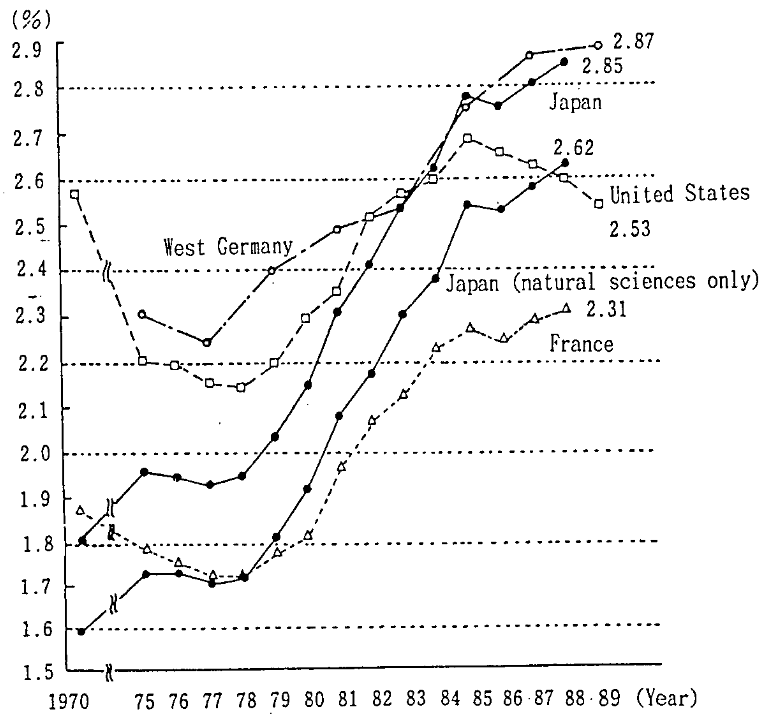


Notes) 1. For the purposes of international comparison, the humanities and social sciences are included for all countries. In the case of Japan, R&D expenditures for the natural sciences, a portion of the total figure, are also indicated.

2. For the United States, 1987 figure is provisional and 1988 and 1989 figures are estimates.

3. For France, figures for 1988 and 1989 are provisional.

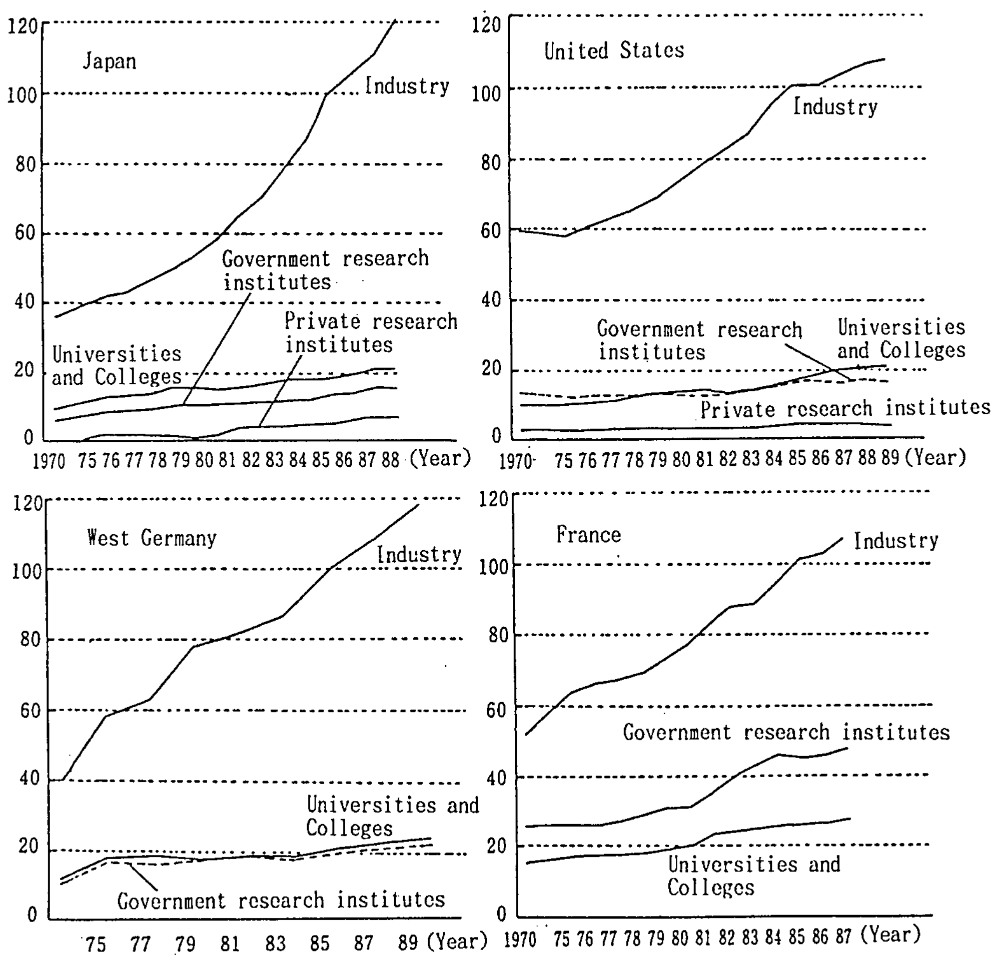
Figure 16 Changes in R&D Expenditures as a Proportion of GNP for Major Countries



Notes) 1. For the purposes of international comparison, the humanities and social sciences are included for all countries. In the case of Japan, R&D expenditures for the natural sciences, a portion of the total figure, are also indicated.

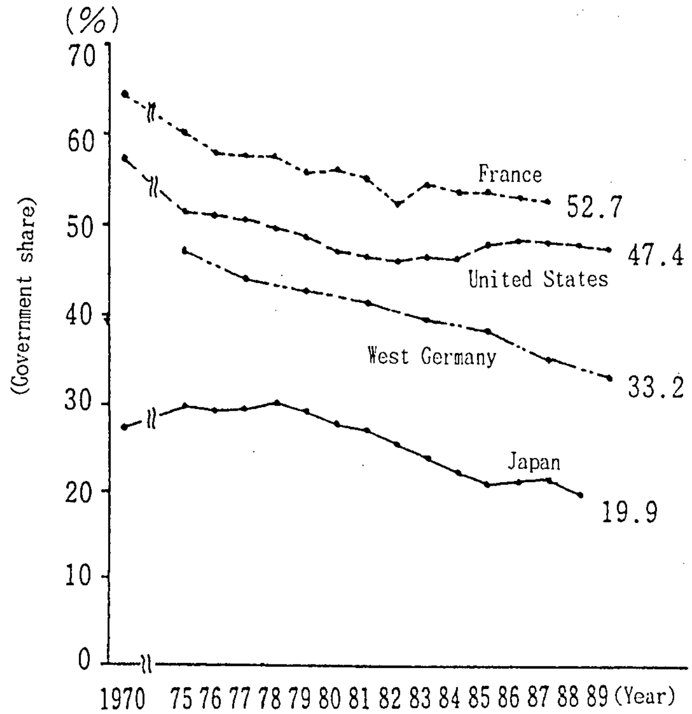
2. For the United States, 1987 figure is provisional, and 1988 and 1989 figures are estimates.

Figure 17 Growth in Actual R&D Expenditures by Organizations in Major Countries



Notes) 1. Actual research expenditures for all countries, with 1985 R&D expenditures by industry equal to 100.
2. Except for Japan, the humanities and social sciences are included
3. Figures for private research institutes in West Germany and France are included in the figures for government research institutes. (The share of total R&D expenditures accounted for by private research institutes in 1985 was 0.4% for West Germany and 1.0% for France.)

Figure 18 Changes in the Share of R&D Expenditures Financed by Government for Major Countries



Notes) 1. For the purposes of international comparison, the humanities and social sciences are included for all countries.
2. For the United States, 1987 figure is provisional and 1988 and 1989 figures are estimates.

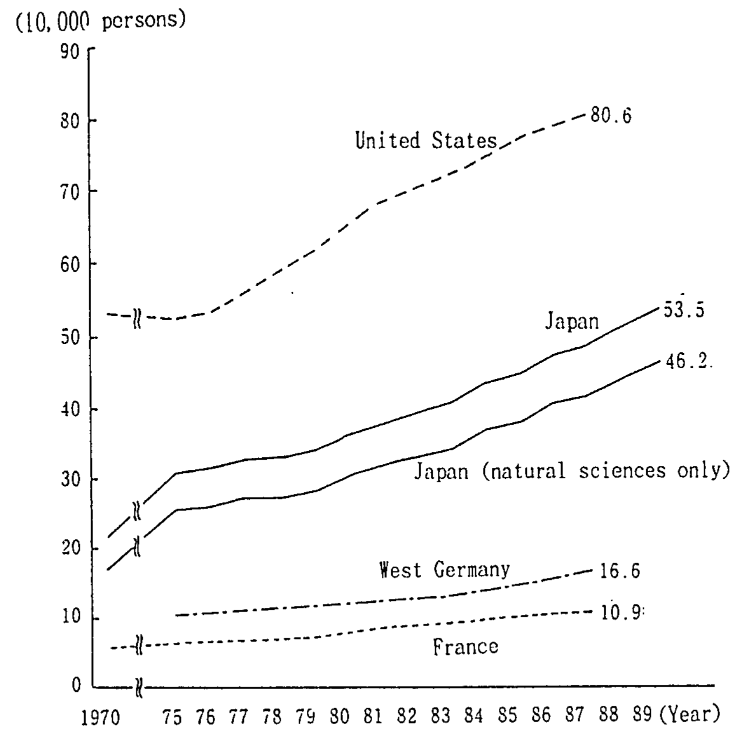
Table 19 Flows of R&D Funds Between Industry, Universities and Colleges, and Government in Major Countries

Source of funds	Organization spending funds	Japan (1988) Value	Share	United States (1989) Value	Share	West Germany (1989) Value	Share
		¥100 mil.	%	¥100 mil.	%	¥100 mil.	%
Government	→ Government	8,627	92.2	29,500	100.0	6,606	92.7
	→ Industry	1,065	1.5	65,500	34.3	4,600	11.5
	→ Unversities and Colleges	10,356	51.4	25,800	69.5	7,132	92.5
Private	→ Government	723	7.7	0	0	* 394	5.5
	→ Industry	70,946	98.3	125,200	65.7	34,853	86.8
	→ Universities and Colleges	433	2.1	1,840	5.0	577	7.5

Source of funds	Organization spending funds	France (1983) Value	Share	United Kingdom (1987) Value	Share
		¥100 mil.	%	¥100 mil.	%
Government	→ Government	7,227	95.6	4,408	84.0
	→ Industry	3,646	22.4	4,522	19.4
	→ Unversities and Colleges	4,424	97.6	3,947	80.1
Private	→ Government	52	0.7	565	10.8
	→ Industry	11,867	73.0	15,912	68.2
	→ Universities and Colleges	58	1.3	270	5.5

Notes) 1. For the purposes of international comparison, the humanities and social sciences are included for all countries.
2. Shares indicates the percentage of total research expenditures for the spending organizations in question, which is accounted for by funds from the indicated source.
3. Values have been converted into OECD's Purchasing Power Parity.
4. For West Germany, the amount spent by "Government" and the amount marked with an asterisk include the amount used or borne by private research institutes.

Figure 20 Changes in the Numbers of Researchers in Major Countries

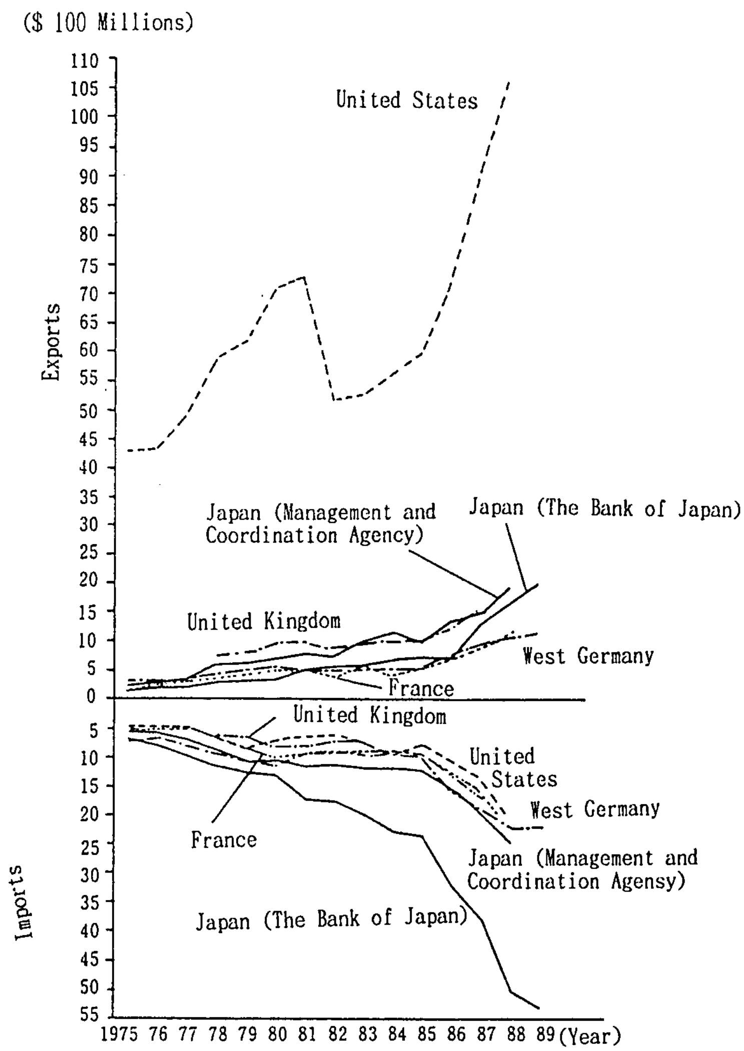


Notes) 1. For the purposes of international comparison, humanities and social sciences are included for all countries. In the case of Japan, the number of researchers involved in natural sciences, a portion of the total figure, are also indicated.

2. When French and West German statistics are unavailable for a particular year, the prior and subsequent years are joined by a straight line.

3. Numbers of researchers are "full-time equivalent" figures for every country except Japan.

Figure 21 Changes in the Value of Technological Trade by Major Countries



Notes) 1. The dollar conversion is based on IMF statistics.
2. Values for all countries are based on totals for calendar years.
3. The references "The Bank of Japan" and "Management and Coordination Agency" refer to figures from the Bank of Japan publication, "Balance of Payments Monthly" and the Management and Coordination Agency Statistics Bureau publication, "Report on the Survey of Research and Development."

Figure 22 High-Tech Products Export Share for Major Countries

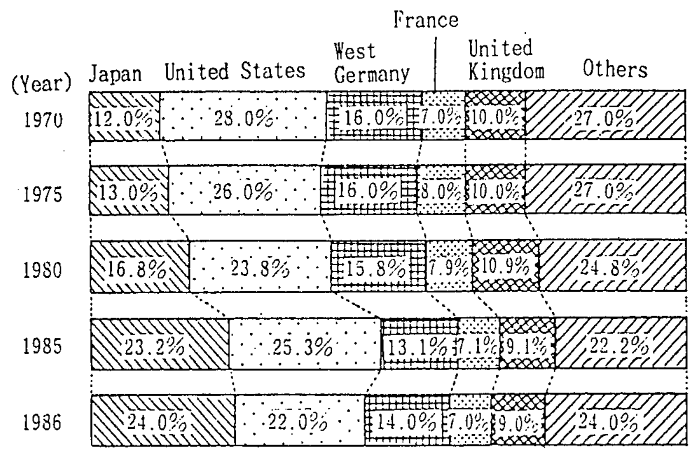
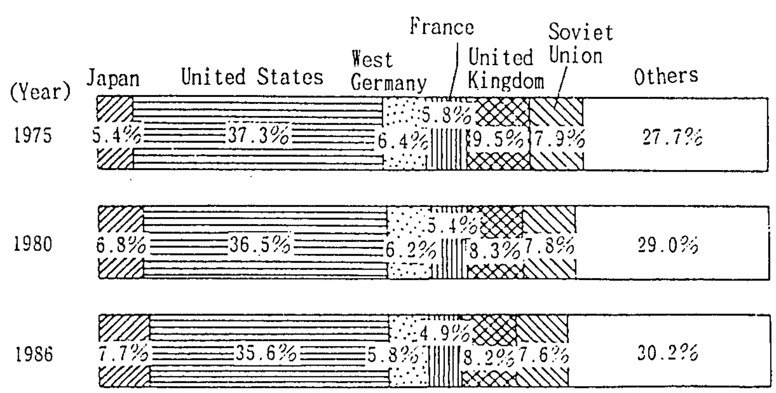


Figure 23 Share of Published Papers by Major Countries



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